DIE-BACK OF VEGETATION IN A MASSACHUSETTS SALT MARSH

James R. Sears, Henry S. Parker
Biology Department
Southeastern Massachusetts University
North Dartmouth, MA

ABSTRACT: Coastal ponds and tidal inlets are bordered by salt marshes dominated throughout most of New England by Spartina patens and Spartina alterniflora. During post-glacial times barrier beaches developed across flooded river valleys and these coarse, salt-tolerant grasses became established and helped to create tidal wetlands protected from wave action of the exposed coastline. Spartina patens (salt marsh hay) occupies relatively high areas of these tidal meadows reached only during spring high tides; in lower areas, S. alterniflora (salt marsh cordgrass) develops dense stands where tidal exchange regularly occurs.

The primary food source of a healthy salt marsh and adjacent ponds and tidal inlets is the annual, above-ground production and subsequent decomposition of Spartina grasses. As such, Spartina production is the basis of a complex marine food web on which a multitude of organisms depend. Salt marshes provide a nursery ground for fish and invertebrates, they offer nesting and feeding habitats for a variety of local and migratory birds, and they act as buffer zones between terrestrial environments and the sea. In addition to these biological and geological roles, salt marshes have significant aesthetic, recreational and economic value.

When extensive die-back of Spartina occurs, not only does the principal food producer disappear but with it most organisms of a complex food web. In this report we document the result of extensive die-back (61% of previously-vegetated marsh) of S. alterniflora of a New England salt marsh. Qualitative and quantitative data based on aerial reconnaissance by infra-red and color photography and ground-level transect studies of vegetation will be presented in analyzing the apparent regrowth of vegetation in the marsh. The possible role of tidal restriction as a major cause of this die-back will be discussed.

Salt marshes fringe tidal wetlands throughout the east coast of temperate North America (1) and are dominated by two coarse grasses, Spartina alterniflora (salt water cordgrass) and S. patens (salt marsh hay). These dominant and salt-tolerant grasses characteristically form meadows and are subject to

1981

periodic submergence in drowned river valleys and behind barrier beaches. We have been studying a salt marsh in the Town of Dartmouth, Massachusetts. The marsh has suffered severe die-back of its vegetation, principally *Spartina alterniflora*, to the extent that by 1980 at least 60% of the previously vegetated marsh had become barren of vegetation. Based on four years of observations, we report here on the probable role of severe tidal restriction in causing this marsh grass die-back and the subsequent slow recovery, though limited, of vegetation in this marsh since 1980.

The value of salt marshes has long been recognized. In the 18th and 19th centuries, and even today in restricted areas, salt marsh hay has provided fodder, mulch, and insulation for New England farmers. Productivity of coastal marshes is high and in some cases exceeds that of productive agricultural land (2). The primary source of food produced in a healthy salt marsh and adjacent ponds and tidal inlets is from the annual, above-ground production and subsequent decomposition of *Spartina* grasses. As such, *Spartina* production is the basis of a complex, marine food web on which a multitude of organisms depend. Salt marshes also provide nursery and feeding grounds for a variety of local and migratory fish, invertebrates and birds and thus form an important link in the overall productivity of coastal waters. They may also play an important role in nutrient cycling in coastal waters and act as a "filter" for biological and chemical pollutants of terrestrial origin. Geologically, marshes are important as buffers between terrestrial and marine zones by stabilizing coastal sediments and checking coastal erosion. The aesthetic value of marshes in New England is almost impossible to assess quantitatively but, given that coastal parts of southeastern Massachusetts have received the highest possible scenic rating in the Massachusetts *State Inventory of Scenic Landscapes*, the aesthetic value of salt marshes is clearly recognized. The overall economic worth of marshes has been estimated at more than $80,000 per acre (3).

Because of the clear dominance of *Spartina* in these coastal environments, the productivity of a salt marsh depends, in large part, on the health of these grasses. Their condition reflects the biological pulse of the marsh and their loss has considerable geological, economic, aesthetic, and recreational significance.

Characteristically, salt marshes can be differentiated into three distinct zones which correspond to increasing elevation and decreasing durations of submergence. The lowest zone is vegetated by a variety of drifting or attached algae and eelgrass, *Zostera marina*. A tall form of *Spartina alterniflora* may be found growing along the edges of channels, creek banks and ditches.

The next highest zone, the "low marsh" comprises the intertidal area from approximately mean sea level to the upper range of neap tide. Depending on the degree of tidal exchange between the marsh and coastal waters, the low marsh is generally submerged on every flood tide. *Spartina alterniflora* dominates the low marsh where it forms dense, continuous stands.

The highest zone, the "high marsh", is usually only a few centimeters higher than the "low marsh" but, because of this elevation difference, the "high marsh" is flooded only during spring flood tides and storm tides. Spartina patens dominates the high marsh where it mixes with several other grasses, rushes, and other flowering plants (viz. Distichilis spicata (spike grass), Juncus gerardi (black rush), and the saltworts (Salicornia spp.)). It may mix with a short form of S. alterniflora at its lower elevations.

Factors affecting the zonation and health of these and other marsh plants include: frequency, duration, and height of tidal flooding; water and soil salinity; relief of the substratum; nutrient composition and availability; composition of the sediment; existence of natural or man-induced toxins in sediment or water; competition between species; natural disturbances including scouring by ice; covering by storm-carried debris; erosion and prolonged submersion; and man-made alterations or disturbances including diking, ditching, and filling, or other activities which may reduce or otherwise alter tidal exchange. Probably the most important of these factors is tidal exchange since different species have different tolerances to submersion and water saturated peat. Spartina alterniflora can withstand submergence much longer than most other plants of the salt marsh but even it does not tolerate continuous submergence for extended periods of time (4).

With this brief description of the characteristics of a healthy salt marsh, and some of the factors which affect the health of marshes in New England, we will now address the phenomenon of marsh grass die-back in a salt marsh in South Dartmouth, Massachusetts. This history of marsh grass die-back is sparse in the literature and there are few documented cases of the death of expanses of salt marsh vegetation anywhere in the world. Die-back of Spartina was first reported in Great Britain (5), (6) in 1959 and Linthurst and Seneca (7) have reviewed reports of marsh grass die-back in Louisiana and North Carolina.

There are apparently no reports of major marsh grass die-back in New England other than a recent unpublished report (8) of Spartina die-back in a salt marsh on Cape Cod. This study is the only documented case of extensive die-back in New England of which we are aware.

Our program of study of the salt marsh in question began in the summer of 1980 when, based on aerial and ground reconnaissance and color (Figure 1) and infrared aerial transparency slides, a map (Figure 2) was prepared which showed that 60% of the previously vegetated parts of the marsh were barren of vegetation at a uniform elevation throughout the marsh.

We attributed the die-back to a series of events which resulted in severe restriction of tidal exchange through a culvert extending between the marsh and Buzzards Bay. We believe that marsh grass roots, rhizomes, and shoots were killed by resultant waterlogging and anoxia in sediments as well as from excessively high salinity occurring when shallow pools of standing water underwent evaporation during dry periods. Circulation within the marsh, and drainage of its tidal flats, was further hindered by dikes which were formed from deposition of side-cast spoils from the digging of mosquito ditches (Figure 3). The

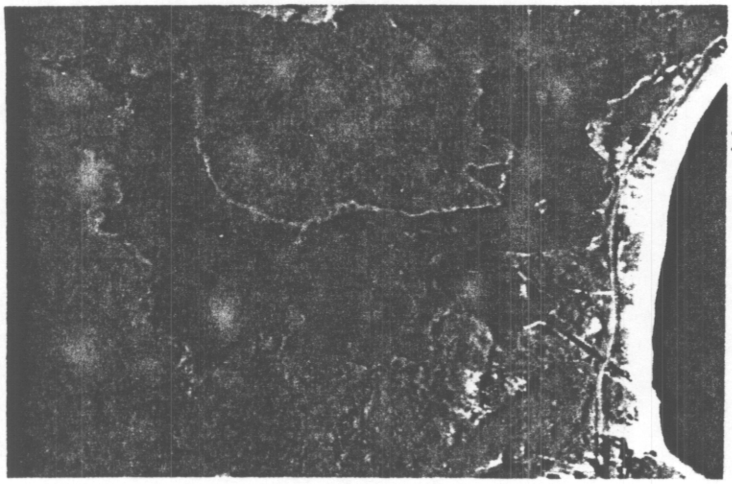


Figure 1. Copy of Infra-red aerial photograph of the salt marsh taken September 1983 from an elevation of ca. 2500 feet. Buzzards Bay is to the right and connects to the marsh via the narrow, straight channel from the beach to the first marsh embayment. A 30" dia. culvert runs from the open channel to Buzzards Bay beneath the beach in the lower right. Sixty percent of the marsh flats have suffered Spartina die-back.

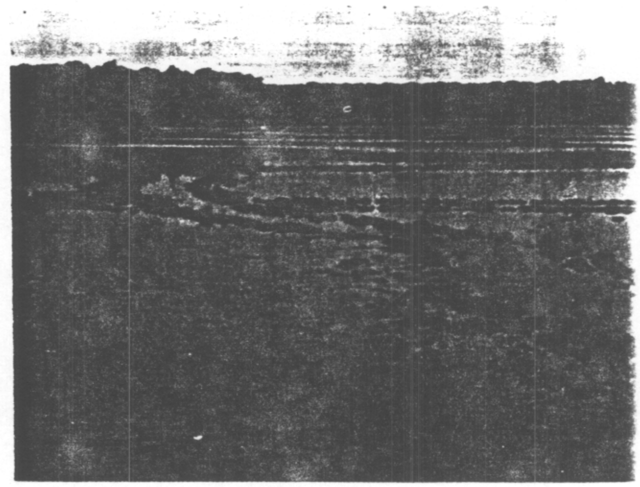


Figure 3. Dikes formed from side-cast dredge material cast along edges of mosquito ditches. These dikes reduce water circulation, and in some areas of the marsh, retard or prevent complete drainage during tidal cycles. Water is covering panne marsh shown here. Prior to die-back, all areas between the channels and the mosquito ditches were vegetated.

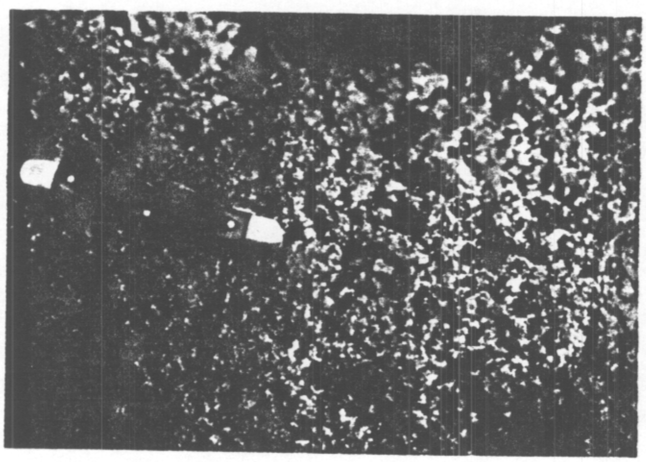


Figure 4. Salt crystals which have formed on the evaporative surface of side-cast dredge spoils inhibit all vegetation from becoming established in those areas. High salinity occurs on the dikes and on panne marsh where water accumulates in depressed areas during times of high evaporation.

Sears Figure 2

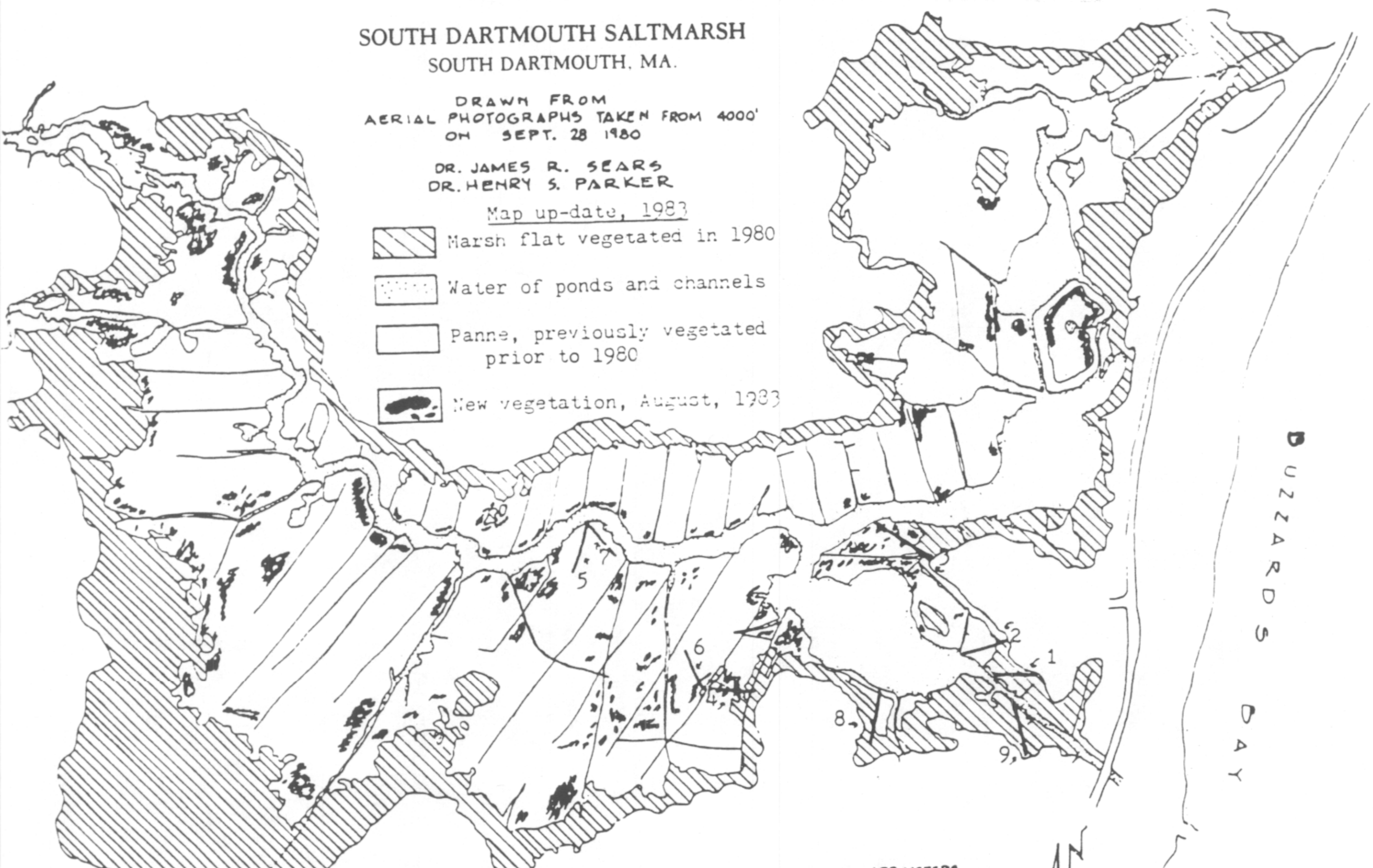


Figure 2. 1983 up-date of 1980 map showing positions of new vegetation as of August, 1983 and locations of Transects 1-9.

"wicking" action of these dikes also causes excessive salinity and salt crystalization on their surfaces during periods of evaporation (Figure 4).

From June, 1981, through August, 1983 we monitored the marsh vegetation by quantative sampling of $1/4m^2$ quadrats along a series of permanent transects established at selected areas of the marsh. Data for quantitative transect studies made between 1981 and 1983 are photographically presented in Figures 5 a/b - 9 a/b and are shown graphically in Figures 10-14.

Observations made through August 1983 lead to several generalizations regarding die-back and regrowth of marsh vegetation. Based on four years of observations and three years of quantitative sampling and analyses, die-back has apparently been arrested since June 1981 owing to restoration of daily tidal flushing. It is apparent that recolonization has occurred on some of the previously denuded areas of the marsh. All quadrats in Transects 1-5 which had been at least partially vegetated in June 1981 have shown an increase in percent vegetation cover (Table 1) and, except for Transect 2, vegetation cover has at least doubled since the transects were established. Percent cover by Spartina alterniflora increased in almost all monitored transects adjacent to existing stands of this plant between 1981 and 1983 (Figs. 10-13). Away from existing stands, where Spartina suffered complete die-back (e.g. Transect #5 (Fig. 14)), there has been almost no recolonization by this genus. Only in those areas distant to existing vegetation which are well-drained has S. alterniflora developed.

While S. alterniflora regrowth accounted for much of the new vegetation, colonization by Salicornia europaea was also important. In those quadrats which had suffered 100% die-back by 1980, most subsequent regrowth has been by S. europaea. This plant is tolerant of higher salinities than is either species of Spartina. S. europaea has seeded and colonized barren sediment and is the initial colonizer of panne marsh, as was also noted for other marshes (7). Expansive areas of new vegetation indicated in Figure 2 mainly represent stands of Salicornia.

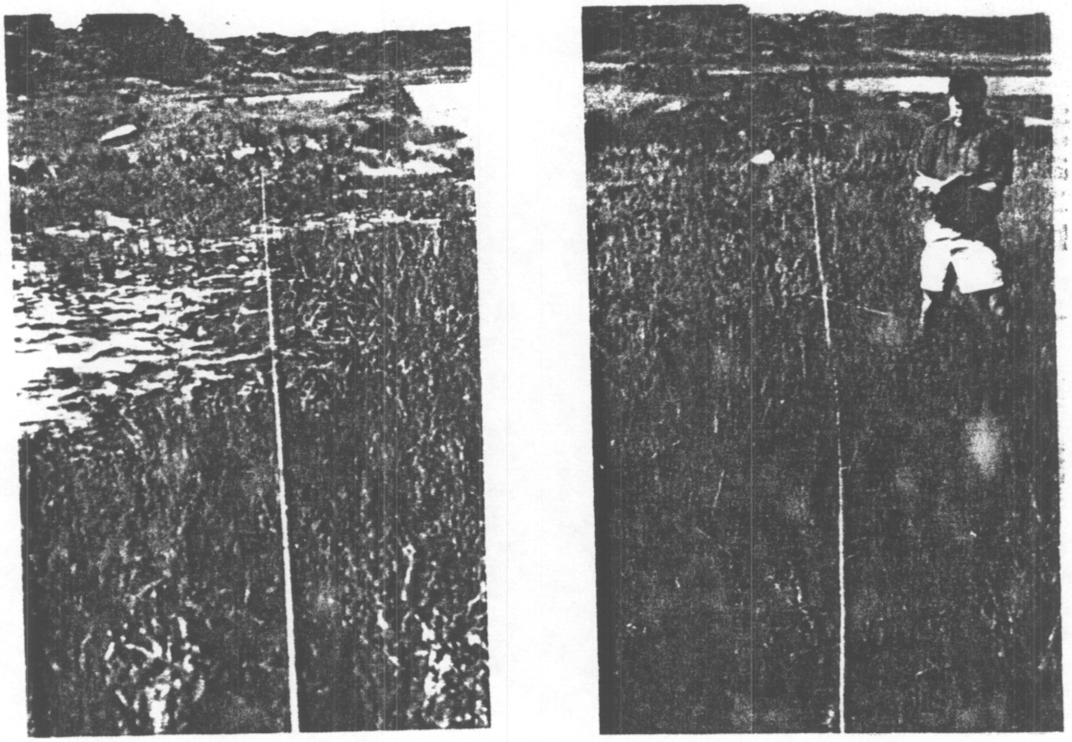
A comparison of aerial photographs taken in 1980 and 1983 (Figsures 15 a&b) reveal accretion of a delta inside the main entrance channel to the marsh. The deposits are made up of drift vegetation, largely Zostera marina (eel grass) and Codium fragile (a sponge-like green seaweed), presumably carried into the marsh along with suspended sediments, by incoming tidal waters. Net transport of sediments in most New England coastal marshes and tidal inlets is inward toward the marsh or embayment (9).

There are two questions that can be posed concerning the condition of vegetation, and thus the entire biology of the salt marsh studied. The first of these deals with historical events, namely: What were the inital causes of marsh grass die-back? The second deals with current conditions; why is regrowth of S. alterniflora so slow in comparison to reports for the reestablishment of grasses in other marshes having suffered die-back (7), (8).

Table 1. Percent cover by total vegetation of initially (6/81) vegetated quadrats of transects 1-5. The total number of quadrats/transects vegetated in June 1981 and again in August 1981 are indicated by N_v/N_t.

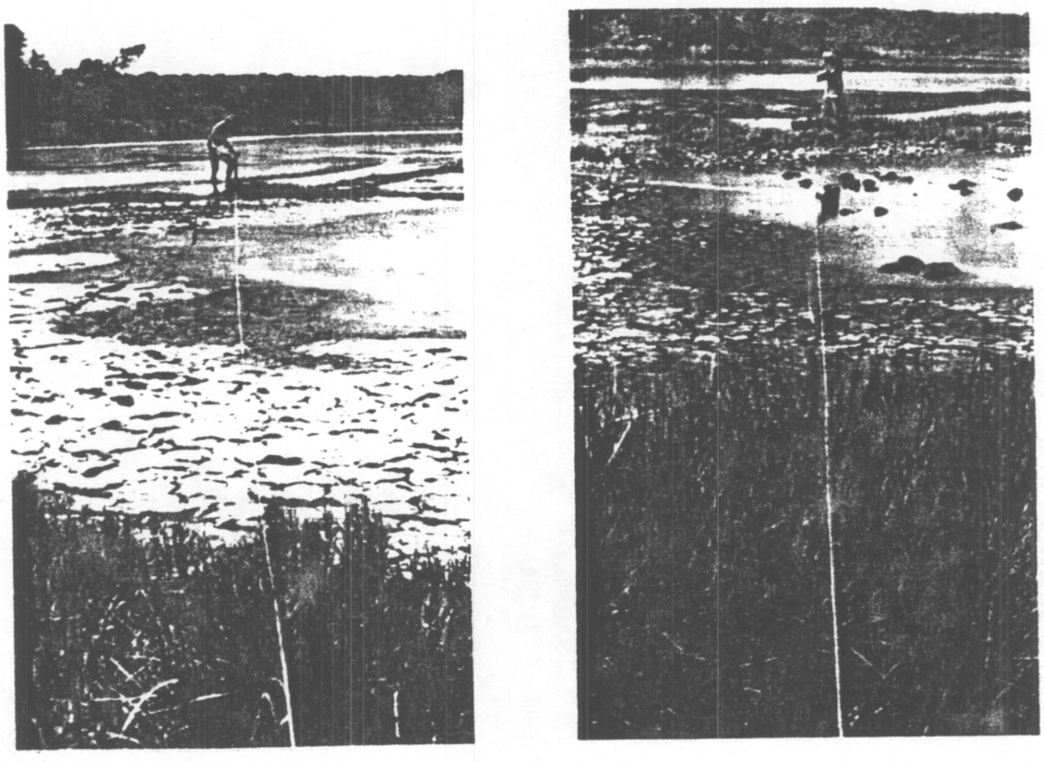
Transect no	N_v/N_t 1981	N_v/N_t 1983	6/16/81	9/29/81	8/25/82	8/17/83	Percent change from 6/81 - 8/83
1	11/11	11/11	37.7	65.9	82.7	81.8	+ 117
2	5/15	6/15	44.0	57.0	74.0	84.0	+ 91
3	16/16	16/16	30.6	58.4	75.6	84.7	+ 176
4	15/16	16/16	28.7	50.7	59.1	71.0	+ 147
5	4/16	11/16	3.3	8.8	3.0	13.7	+ 315

N_v/N_t = Number of quadrats vegetated/total number of quadrats in each transect



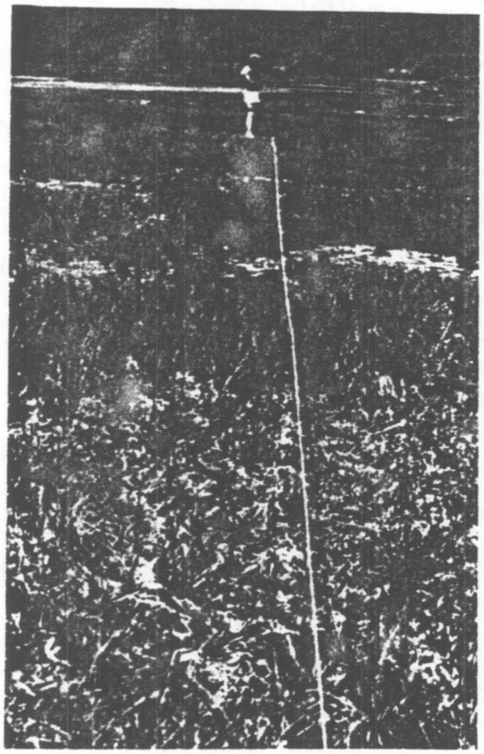
1981 (a) 1983 (b)

Figures 5a and 5b: Transect #1 in June, 1981 (a) and August, 1983 (b). Spartina increased 232% in percent cover from 6/81 to 8/83. Salicornia colonized panne areas of the marsh in 1982 and 1982 by seedling development.

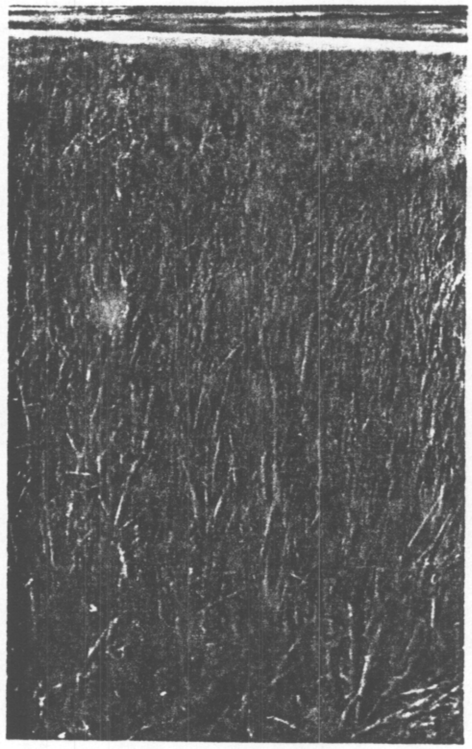


1981 (a) 1983 (b)

Figures 6a and 6b: Transect # 2 in June, 1981 (a) and August, 1983 (b). Spartina cover increased 19% in percent cover from 6/81 to 8/83 in elevated areas and adjacent to pre-existing Spartina. In areas of standing water where waterlogging and extreme fluctuations in salinity occurred seasonally, vegetation has not re-established. Note dried, cracked mat of Cyanobacteria at edge of panne.

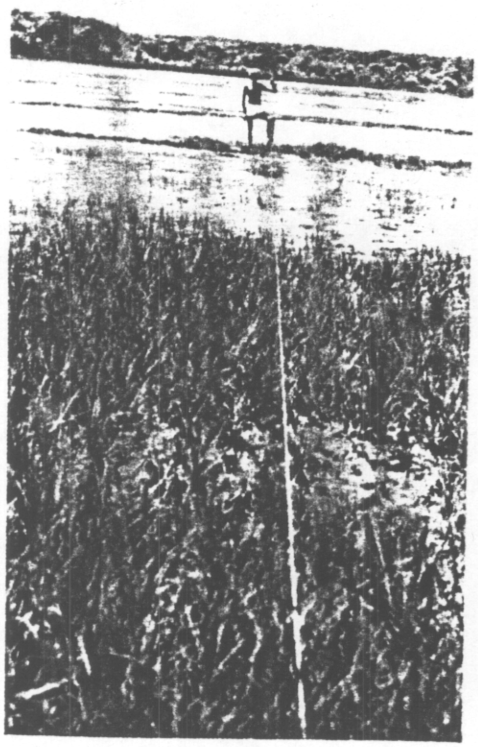


1981 (a)

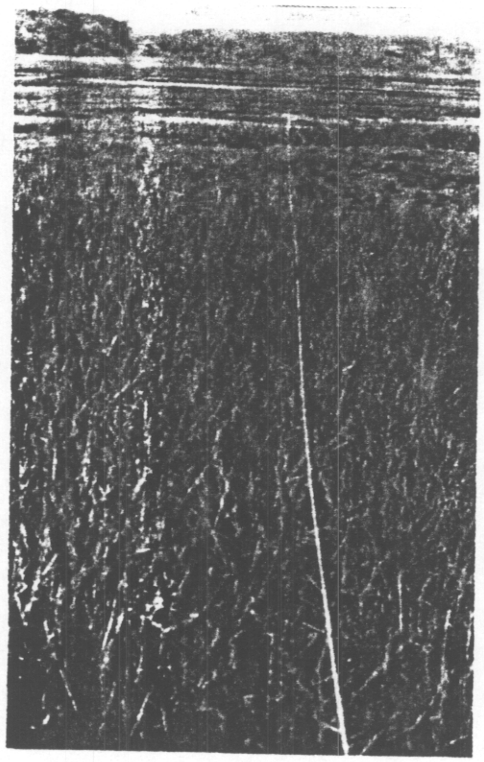


1983 (b)

Figures 7a and 7b: Transect #3 in June, 1981 (a) and August, 1983 (b). The area of die-back in the foreground of the 1981 photograph had become almost completely recolonized by Spartina alterniflora by vegetative tillering by August, 1983. The mean percent coverage by S. alterniflora increased 354% along the transect from 1981 to 1983. This area is moderately well drained.

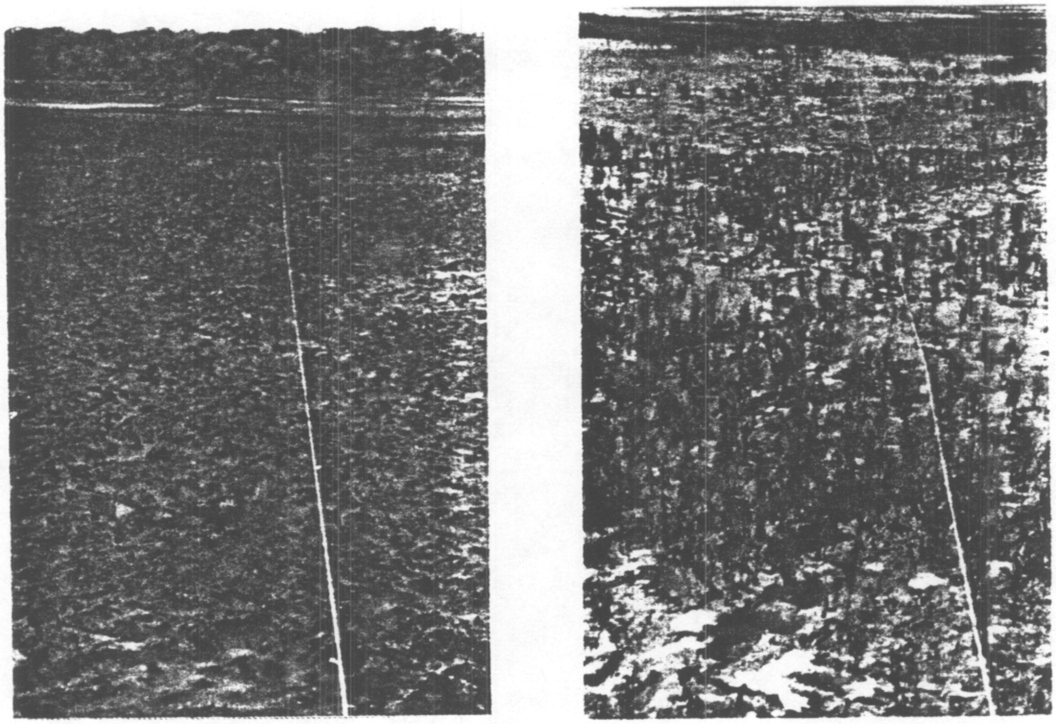


1981 (a)



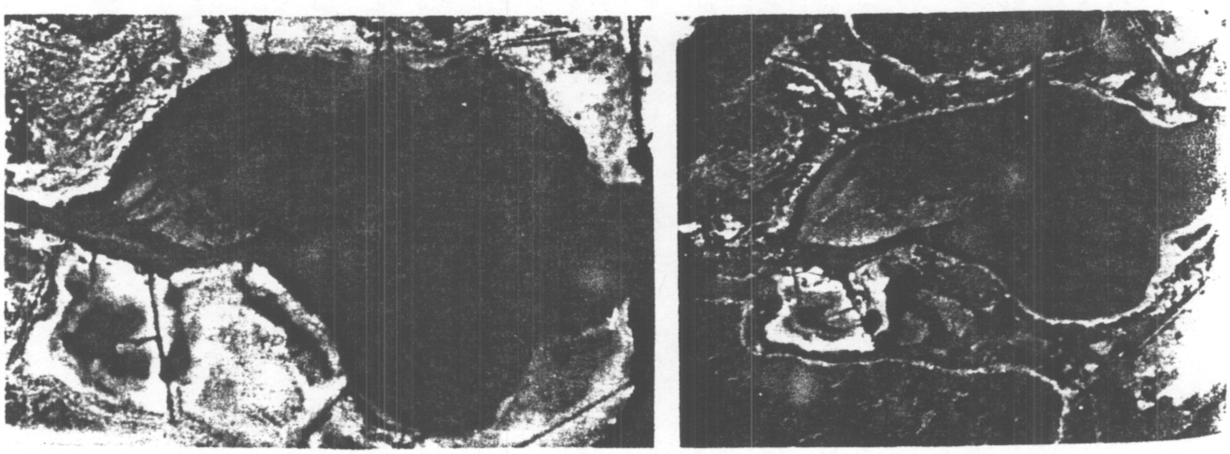
1983 (b)

Figures 8a and 8b: Transect #4 in June, 1981 (a) and August, 1983 (b). S. alterniflora increased 154% between 1981 and 1983. Barren areas near channel in 1981 had become heavily colonized by Salicornia by 1983 and areas of die-back in the foreground in 1981 had become revegetated by 1983.



1981 (a) 1983 (b)

Figures 9a and 9b: Transect #5 in June, 1981 (a) and August, 1983 (b). A single clump of S. alterniflora occurred along the transect in 1981; by 1982 this clump had begun to decline and had disappeared by August, 1983. Salicornia, tolerant of higher salinity than Spartina, became widely established by natural seedling development and accounts for all of the vegetation seen in foreground of the 1983 photograph. The panne along this transect was depressed and subject to evaporation and subsequent salt build-up in its sediments during summer months. Salicornia is characteristic of areas subject to high salinity and is also a primary colonizer of panne marsh.



1980 (a) 1983 (b)

Figures 15a and 15b. Aerial view of delta at the embayment (west) end of the open, entrance channel in September, 1980 (a) and 3 years later in August, 1983 (b). Note accretion of sediments at the embayment end of the delta by 1983, these reflecting a net influx of sediments into the marsh. If left undisturbed, the delta will continue to expand into the marsh embayment, thus reducing the volume of water that the marsh can accomodate, and a decreased tidal prism. Note barren, depressed areas of panne marsh surrounding embayment. Straight lines are mosquito ditches.

Concerning the first question, results obtained during the past four years support our initial hypothesis that die-back in the salt marsh prior to 1980 was ultimately attributable to severe tidal restriction resulting from intermittent blockage of the culvert and chronic, partial blockage of the marsh inlet channel prior to 1981. We believe that this blockage engendered the following sequence of events:

1. Standing water accumulated on the high marsh resulting in:
    a. sediment waterlogging and associated anoxia,
    b. subsequent H_2S build-up and stressful changes in sediment ion composition, and
    c. intermittent, stressful elevation of salinity in shallow pools and sediments on the marsh surface during times of high evaporation rates in the summer.

2. Stagnation and fouling of standing water resulting from decomposition of organic matter.

3. Widespread death of marsh vegetation (primarily *Spartina alterniflora*) occurring at a uniform elevation (subjected to standing water) on the marsh.

The factors inhibiting recolonization are related to those causing die-back but are somewhat different. Regrowth has been hindered in previously denuded areas of the marsh because of standing water and the concomitant adverse conditions that result. Subsequent to die-back, roots and rhizomes decomposed and resulted in settling and erosion of the peat substratum in the absence of vegetative cover, thus creating depressions over the panne marsh. Water collected in these depressions and caused waterlogging of sediments and, during dry periods, an increase in salinty due to evaporation. Both are conditions which discourage seed germination and growth by *Spartina*.

If tidal exchange is not further restricted by culvert blockage, or accretion of the tidal delta to the point of reducing water exchange, it appears likely that slow regrowth of grasses will continue by gradual expansion of currently vegetated areas through vegetative tillering. Colonization and regrowth of denuded areas is likely to be severely limited and slow because of the continued presence of standing water in shallow depressions on large areas of the marsh. Reproduction by seed production will be limited to well-drained areas of the marsh because of the conditions of depressed areas adversely affecting seed germination.

QUESTION PERIOD:

Q. Is not some die-back and the appearance of salt pannes typical of most salt marshes?

Dr. Sears: Yes, pannes occur commonly either as dead, flat, usually somewhat depressed areas in relation to surrounding elevations, or sometimes as actual ponds, but these are of limited size and nowhere near the extent of the dead areas of the marsh we studied.

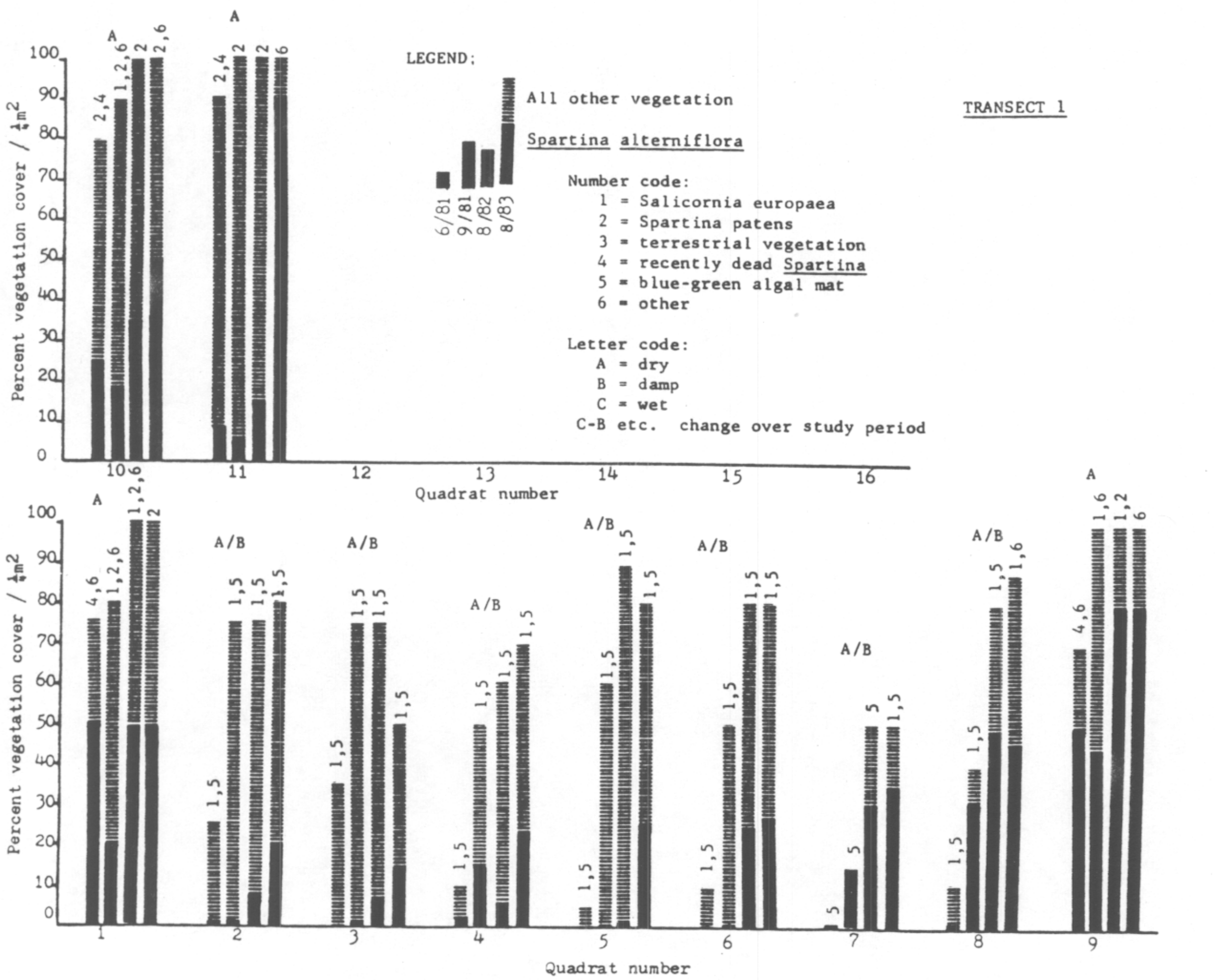
Q. Could a rise of sea level subsequent to the construction of the culvert have caused the die-back?

Dr. Sears: The long-term existence of salt marshes depends on a rising sea level and in this case a rise might actually help the marsh if it would result in increased tidal exchange. However, I believe that the period of time has been too short to have been a factor in this die-back.

Q. Once die-back starts can it be held in check or be reversed? How long would it take? What suggestions have you to help reverse the trend of die-back?

Dr. Sears: First, die-back in the Dartmouth salt marsh is not a disease, i.e. it is not communicable. Once its causes are known, die-back can be stopped by rectifying the problem(s) and, if there are no secondary problems such as there are with the depressions of the marsh in question, die-back can be reversed. The time it will take to bring a marsh back depends on the extent of die-back and the degree to which sexual reproduction (seed production and germination) is successful. To rectify problems in the Dartmouth marsh we have suggested a number of recommendations. Foremost among them are to take steps to assure severe blockage does not reoccur and to drain the depressed areas. Unhindered tidal exchange is the key to maintenance of a healthy salt marsh.

sears figure 10



Figures 10 - 14: Percent vegetated cover in $\frac{1}{4}$ m^2 quadrats along a monitored transect in the South Nonquitt, MA salt marsh in June, 1981; September, 1981; August, 1982 and August, 1983. Quadrat numbers along the horizontal axis of the graphs begin with number 1 at the water's edge and extend at 2 m intervals to the terrestrial vegetation along the shore. Code numbers above histogram bars represent predominant vegetation type in quadrats (other than S. alterniflora). Code letters indicate qualitative indices of relative sediment surface moisture (A = dry; B = damp; C = wet)

Figure 10.

sears figure 11,12

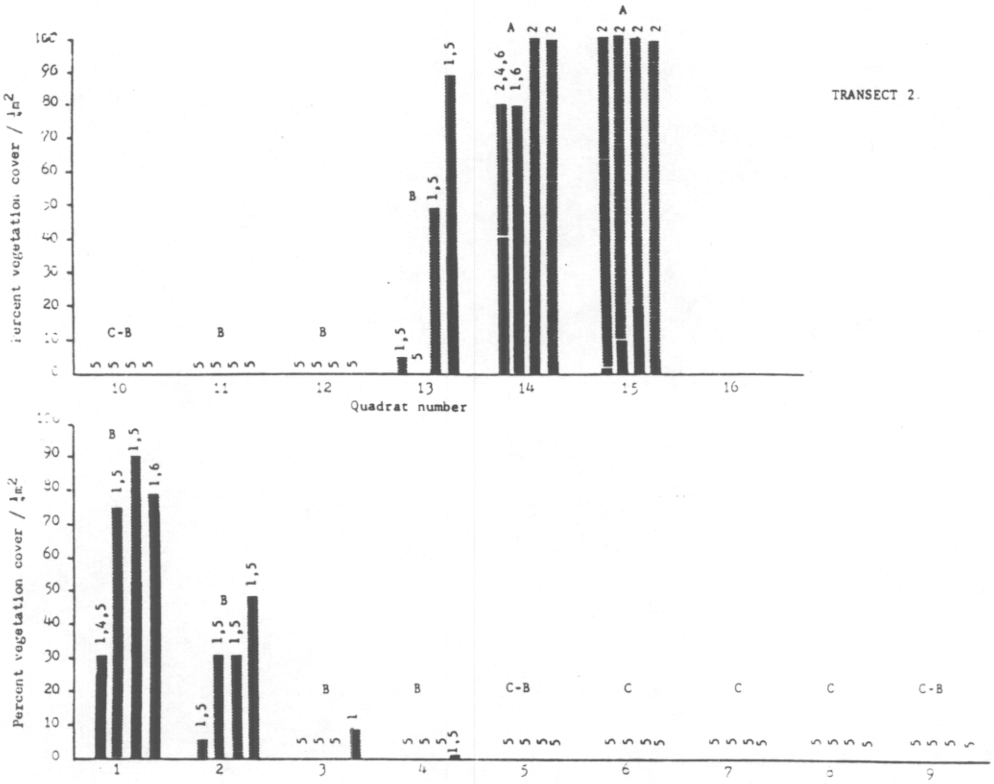


Figure 11.

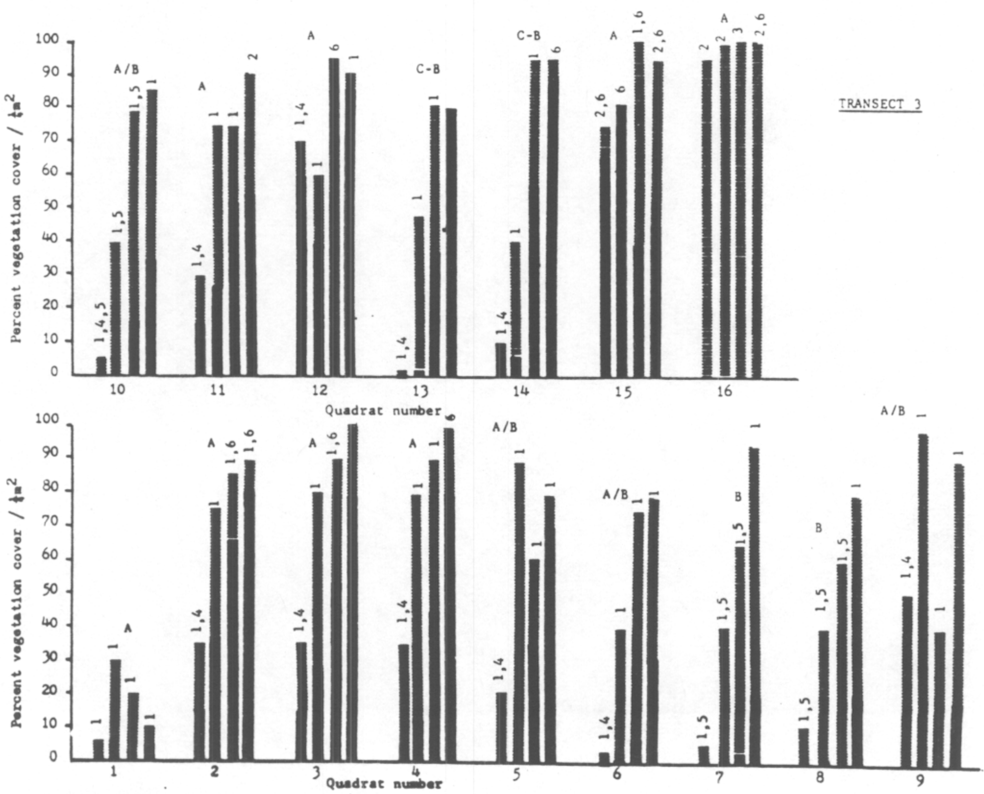


Figure 12.

Figure 13,14

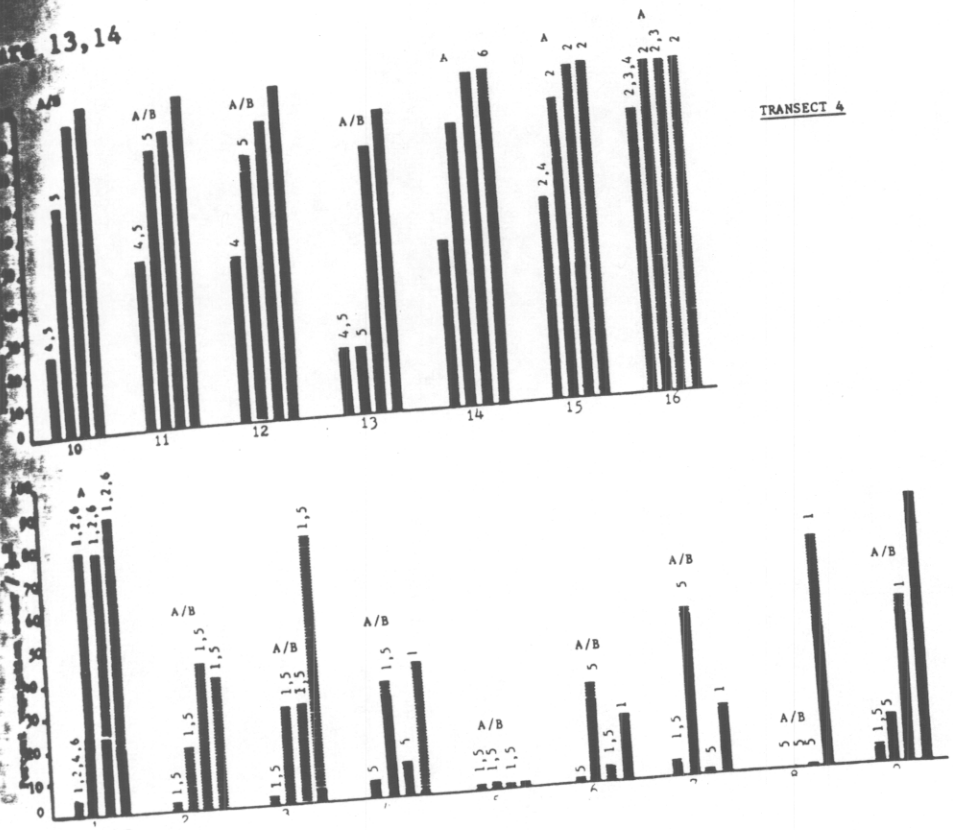


Figure 13.

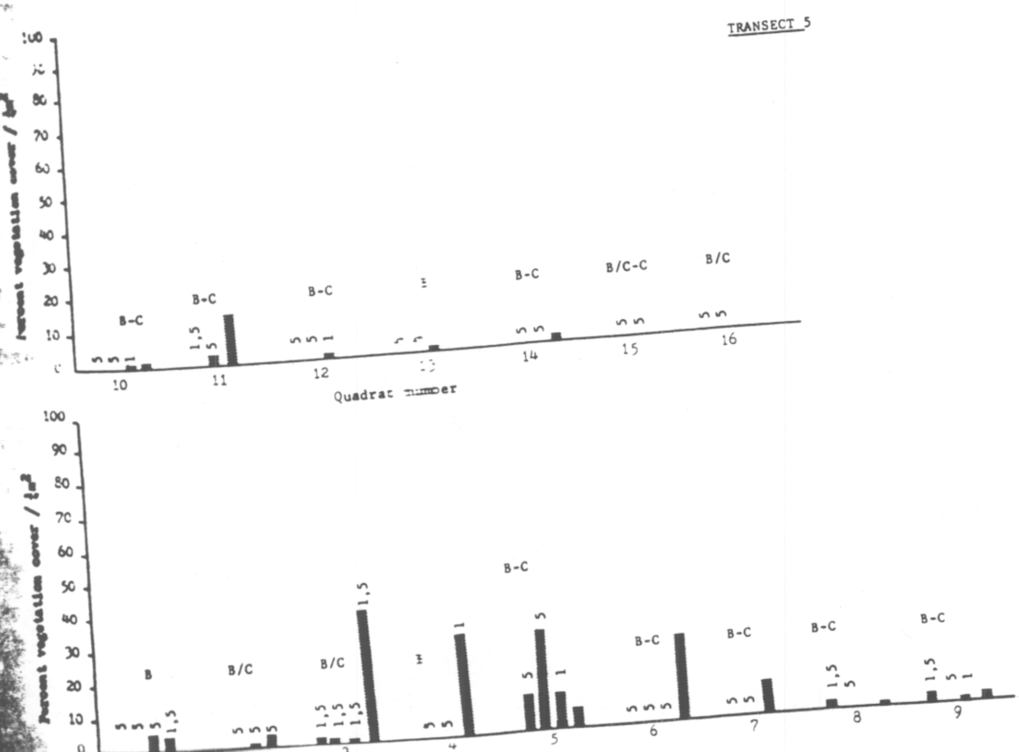


Figure 14.

REFERENCES

(1) Niering, W.A. and R.S. Warren. 1980. Vegetation patterns and processes in New England salt marshes. Bioscience 30:301-307.

(2) Odum, E.P. 1961. The role of tidal marshes in estuarine production The N.Y. State Conservationist 15:12-15.

(3) Gosselink, J.G., E.P. Odum and R.N. Pope. 1974. The value of the tidal marsh. Louisiana State University Center for Wetlands Resources, Pub. no. LSU-SG-74-03. Baton Rouge, LA.

(4) Redfield, A.C. 1972. Development of a New England salt marsh. Ecol. Monogr. 42:201-237.

(5) Goodman, P.J., E.M. Braybrooks and J.M. Lambert. 1959. Investigations in "Die-back" in Spartina townsendii Agg., I: The present status of Spartina townsendii in Britian. J. Ecol. 47:651-677.

(6) Goodman, P.J., W.T. Williams. 1961. Investigations into "die-back" in Spartina townsendii Agg., III. Physiological correlates of "die-back". J. Ecol. 49:391-398.

(7) Linthurst, R.A. and E.D. Seneca. 1980. Dieback of Spartina alterniflora Loisel in the Lower Cape Fear Estuary of North Carolina: an experimental approach of reestablishment. Environ. conserv. 7:59-66.

(8) Nickerson, N. 1985. Water Quality in Tidal Inlets and Salt Ponds - marshes, stagnation, mosquitos, and public health. These proceedings pp. 17-24.

(9) Fitzgerald, D. 1985. The Development of Coastal Bays and Tidal Inlets. These proceedings pp. 25-44. Also personel communication.

Dr. James R. Sears and **Dr. Henry S. Parker** are both members of the faculty of the Biology Department of Southeastern Massachusetts University. Dr. Sears, an Associate Professor, holds a Ph.D. from the University of Massachusetts and specializes in coastal botany and the ecology of marine algae. Dr. Parker, an Assistant Professor, holds a Ph.D. from the University of Rhode Island. His research includes the effects of variable nutrients on the ecology of salt ponds and estuaries.

Dr. James Sears
Biology Department
Southeastern Mass. University
North Dartmouth, MA 02747

(617)-999-8215

Dr. Henry Parker
Biology Department
Southeastern Mass. University
North Dartmouth, MA 02747

(617)-999-8210